1 Process Precontrol

1.1 Summary

Precontrol is a statistically sound method of controlling a process based on decision zones determined from specification limits. The quality characteristic must be measurable and must be controllable by the operator. The method does not require historical data like SPC and gives the operator immediate information on the state of the process.

1.2 Application Strengths and Weaknesses

1.2.1 Application Strengths

The Precontrol method is useful in short and long run applications. Process history is not required and operators make immediate control decisions beginning with the first piece. Operators are not required to make calculations or record their observations. Simple records can be kept if the customer requires evidence of process control, however, get their approval first. Precontrol is statistically sound and provides evidence of process control.

1.2.2 Application Weaknesses

Precontrol suffers from higher risks than SPC. Usually no data is recorded so the benefits of collecting and interpreting long term data are not realized. Customers may reject this method as being insufficient.

1.3 Assumptions

The process capability is at least Cp=1.0 and the quality characteristic is normally distributed (Besterfield). The process need not be capable nor does the quality characteristic need to be normally distributed (Juran).

1.4 Process Precontrol Procedures

1.4.1 Procedure for Two-Sided Spec Limits

1. Determine the upper and lower specification limits of the quality characteristic (LSL and USL).

2. Divide the tolerance into quarters by identifying the nominal part dimension (Xo) and two precontrol points midway between the nominal and the spec limits (PCL and PCU).

3. The region between the precontrol points PCL and PCU is the green (run) zone. The regions between the spec limits and the precontrol points are the yellow (warning) zones. The regions outside of the spec limits are the red (reset) zones.

4. In the start-up phase of precontrol the operator makes and inspects one part at a time. Each part classified as green, yellow, or red. The operator continues to make and inspect parts as long as they are judged to be green or yellow. No adjustments to the process are made unless a red or two consecutive yellow parts are produced. Then the process is stopped, adjusted, and restarted. the start-up phase continues until the operator produces five consecutive green parts.

5. The run phase of precontrol begins when the operator has completed the start-up phase by producing five consecutive green parts. In this phase the operator runs the process and draws samples of two parts at regular intervals. This continues as long as both parts in the sample are green or green and yellow. When a red part or two yellow parts are produced the process is stopped, adjusted, and restarted in the start-up phase. The interval between samples is determined from experience and should be set on the basis of how often the process needs to be restarted. A good -rule is that samples of two should be drawn at intervals of one-sixth of the time between adjustments. For example, if the process requires adjustment every two hours then samples of two should be drawn every $120/6 = 20$ minutes.

Example 1 *An operator is to run a process using precontrol. A two sided spec is to be used:* ± 30 *(the data is coded to the nominal value). To determine the decision limits he divides the tolerance into quarters and defines the reset, warning, and run zones:*

Red	|	*Yellow*	|	*Green*	|	*Yellow*	|	*Red*
	-30		-15		15		30	
	LSL		PCL		PCU		USL	

From experience the operator knows that he can expect to adjust the process, once its running correctly, after about every 120 parts are produced. The operator sets up the process as best he can and makes the first part. Upon inspection he finds that the first part dimension is $x = -33$ *which is out of tolerance and-in the red zone so he adjusts the machine accordingly. The next part produced gives* $x = 18$*, in the yellow zone, so he continues. The third part is* $x = 10$*, in the green zone, so he continues. The next four parts made have dimensions* $x = \{-9, 2, 7, 10\}$ *which are all green. Since five consecutive parts have fallen in the green zone* $x = \{10, -9, 2, 7, 10\}$ *he shifts to the run phase of precontrol.*

Since the operator expects to have to adjust the machine after about 120 parts are made he decides to draw his samples of two parts for inspection in the run phase after every $120/6 = 20$ *parts are produced. He makes 18 parts without inspection and then measures the 19th and 20th part. He finds their dimensions to be* $x = \{10, -15\}$ *(green and yellow) so lie continues to run. Again he makes 18 parts without inspection and then measures the 19th and 20th parts. This time their dimensions are* $x = \{-7, 9\}$ *(green and green) so he continues. The next five blocks of 20 parts give the following part dimensions for their 19th and 20th parts:*

$x = \{-7, -3\}$	*green and green*
$x = \{-5, 4\}$	*green and green*
$x = \{4, -16\}$	*green and yellow*
$x = \{-12, -8\}$	*green and green*
$x = \{-22, -16\}$	*yellow and yellow*

The last sample yielded two parts in the same yellow zone so the process must be adjusted and the operator must return to the startup phase. After making adjustments the next five parts are $x = \{-14, 12, 8, -3, 6\}$ *which are all green so the operator shifts again to the run phase. This cycle is continued until the job is complete.*

1.4.2 Procedure for One-Sided Spec Limit - Total Indicator Reading

1. Determine the upper specification limit (USL).
2. Divide the interval between 0 and the USL in half - this is the precontrol limit (PC).
3. The zone between 0 and PC is the green (run) zone. The zone between PC and USL is the yellow (warning) zone. The zone above the USL is the red (reset) zone.
4. Continue as in steps 4 and 5 of the Two-Sided Spec Limit case.

Example 2 *An operator needs to control surface finish as measured by roughness average* (Ra) *for a CNC milling operation. An upper specification of* $Ra = 5$ *microinches has been set and he believes the process should run stably once it is set up correctly. He uses the one sided spec limit - total indicator reading method to set the precontrol limit to* $PC = 2.5$ *and establishes the following decision zones:*

|	*Green*	|	*Yellow*	|	*Red*
0		2.5		5.0	
		PCU		USL	

The operator sets up, runs, and inspects the first part and finds $Ra = 0.6$ *which falls in the green zone so he proceeds. He runs and inspects each of the next four parts and finds* $Ra = \{0.4, 0.5, 0.7, 0.4\}$ *which gives him five consecutive green parts so he has successfully completed the start-up phase and can move to the run phase. Since he expects the process to run stably without the need for adjustments he decides to inspect* *two parts every four hours. At the end of the first four hours two samples give* $Ra = \{0.5, 0.5\}$ *(green and green) so he continues. At the end of his shift he inspects two more parts and finds* $\{Ra = 0.7, 0.5\}$ *(green and green) so he tells the operator of the next shift that the job can continue without adjustments, that the process is running in the run phase of precontrol, and that samples of two parts should be drawn every four hours*

1.4.3 Procedure for One-Sided Spec Limit - Maximum or Minimum

1. Determine the relevant one-sided spec limit (LSL or USL).
2. There are two possible ways to determine the precontrol limit (PCL):
   (a) Find the measured value of the best part produced in the past, i.e. the part that falls the farthest from the one-sided spec limit. Divide the interval between the spec limit and the best part into two zones determined by the PCL. Position the PCL one quarter of the interval width from the spec limit and three quarters of the interval width from the best part. The zone between the spec limit and the PCL is the yellow (warning) zone and the zone between the PCL to beyond the best part is the green (run) zone.
   (b) Find the part's target value or its historical mean. Divide the interval between the spec limit and the target or historical mean in half. The interval closest to the spec limit is the yellow zone and the interval farthest from the spec limit is the green zone.
3. Continue as in steps 4 and 5 of the Two-Sided Spec Limit case.

Example 3 *An operator needs to determine the precontrol limit for a one-sided spec* $USL = 60$*. From his historical data the smallest part ever observed (i.e. the best part) had size* $x_{smallest} = 20$*. The interval width between the spec limit and the best part is* 40 *units wide and must be divided into two smaller intervals in the ratio of* $1:3$ *or, in measurement units* $10:30$ *so* $PCL = 60 - 10 = 50$*. The zones for the precontrol method are:*

Interval	*Zone*
$0 < x < 50$	*Green*
$50 < x < 60$	*Yellow*
$60 < x < \infty$	*Red*

1.5 Notes

1. Precontrol is subject to larger type I error probability than Shewhart charts and comparable type 2 error probability.
2. Two yellows in the same zone indicate that the process mean has drifted. A pair of yellows in different zones indicate that the process variation is excessive. The action required in each case is different.
3. If the process is capable ($Cp > 1.0$) then five greens will be produced before a pair of yellows in different zones.

1.6 References:

- Besterfield, Quality Control, 3rd Ed.
- Juran, Quality Control Handbook, 4th Ed.